Raspberry Pi

Raspberry Pi (/paɪ/ *PY*) is a series of small single-board computers (SBCs) developed in the United Kingdom by the Raspberry Pi Foundation in collaboration with Broadcom. To commercialize the product and support its growing demand, the Foundation established a commercial entity, Raspberry Pi Holdings, a public company that trades on the London Stock Exchange.[1]

The Raspberry Pi was originally created to help teach computer science in schools, but gained popularity for many other uses due to its low cost, compact size, and flexibility. It is now used in areas such as industrial automation, robotics, home automation, IoT devices, and hobbyist projects.

The company's products range from simple microcontrollers to computers that the company markets as being powerful enough to be used as a general purpose PC.[2] Computers are built around a custom designed system on a chip and offer features such as HDMI video/audio output, USB ports, wireless networking, GPIO pins, and up to 16 GB of RAM. Storage is typically provided via microSD cards.

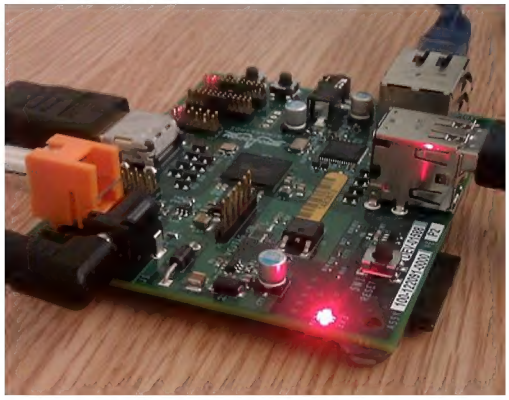
In 2015, the Raspberry Pi surpassed the ZX Spectrum as the best-selling British computer of all time. As of March 2025, 68 million units had been sold.

History

Origins and Launch (2008–2012)

The Raspberry Pi Foundation was established in 2008 by a group including Eben Upton,[1] in response to a noticeable decline in both the number and skill level of students applying to study computer science University of Cambridge Computer Laboratory. The foundation's goal was to create a low-cost computer to help rekindle interest in programming among schoolchildren.[3][4][5]

This mission was inspired by the aims of the BBC Micro computer of the early 1980s, which was developed by Acorn Computers as part of a BBC initiative to promote computer literacy in UK schools.[6] The names "Model A" and "Model B" were chosen as a deliberate homage to the BBC Micro.[7] The name "Raspberry Pi" combines the fruit-themed naming convention used by early computer companies with a nod to the Python programming language.[8]



An early alpha-test board in operation using different layout from later beta and production boards

The first prototypes resembled small USB sticks.[9] By August 2011, fifty functionally complete "alpha" boards were produced for testing,[10] with demonstrations showing them running a Debian-based desktop and handling 1080p video playback.[11][12] In late 2011, twenty-five "beta" boards were finalized,[13][14][15] and to generate publicity before the official launch, ten of these were auctioned on eBay in early 2012.[16][17]

The first commercial Raspberry Pi, the Model B, was launched on 29 February 2012, with an initial price of $35.[18] Demand far exceeded expectations, causing the websites of the two initial licensed distributors, Premier Farnell and RS Components, to crash from high traffic.[19][20][21] Initial batches sold out almost immediately, with one distributor reporting over 100,000 pre-orders on the first day.[18] The lower-cost $25 Model A followed on 4 February 2013.[22]

Raspberry Pi

Various Raspberry Pi computers (Pi 1, Pi 5, Pi 400, Zero 2W and Pico)

Developer	Raspberry Pi Holdings
Manufacturer	Sony (under contract)
Type	Single-board computers
Release date	29 February 2012
Units sold	68 million (as of March 2025)
Operating system	Raspberry Pi OS (default)
Storage	MicroSD slot
Website	www.raspberrypi.com (https://www.raspberrypi.com)

The Raspberry Pi did not ship with a pre-installed operating system. While ports of RISC OS 5 and Fedora Linux were available,[23][24][25] a port of Debian called Raspbian quickly became the standard. Released in July 2012, it was optimized to leverage the Raspberry Pi's floating-point unit, offering significant performance gains.[26][27] Raspberry Pi quickly endorsed it as the official recommended OS, and by September 2013, the company assumed leadership of Raspbian's development.[28]

Corporate Evolution

In 2012, the Foundation restructured, creating Raspberry Pi (Trading) Ltd. to handle engineering and commercial activities, with Eben Upton as its CEO.[29][30] This allowed the Raspberry Pi Foundation to focus solely on its charitable and educational mission. Raspberry Pi (Trading) Ltd. was renamed Raspberry Pi Ltd. in 2021.[29][31] In June 2024, the company went public on the London Stock Exchange under the ticker symbol RPI, becoming Raspberry Pi Holdings.[32][33][34][35]

Post-Launch Production (2012–2014)

Following the launch, the first units reached buyers in April 2012.[36] To address overwhelming demand and initial supply chain issues, the Foundation ramped up production to 4,000 units per day by July.[37][38] The first batch of 10,000 boards was produced in factories located in Taiwan and China.[39][40] A significant strategic shift occurred in September 2012, when manufacturing began moving to a Sony factory in Pencoed, Wales.[41][42] During this period, the hardware was also refined: the Model B Revision 2.0 board was announced with minor corrections, and in October, its included RAM was doubled to 512 MB.[43][44][45]

The post-launch period focused heavily on software and ecosystem development. In August 2012, the Foundation enabled hardware-accelerated H.264 video encoding and began selling licenses for MPEG-2 and VC-1 codecs.[46][47][48] A major milestone for the open-source community occurred in October 2012, when the Foundation released the VideoCore IV graphics driver as free software. While the claim of it being the first fully open-source ARM SoC driver was debated, the move was widely praised.[49] This effort culminated in February 2014 with the release of full documentation for the graphics core and a complete source release of the graphics stack under a 3-clause BSD license.[50]

Product Line Expansion (2014–present)

In 2014, the Raspberry Pi product line began to diversify. April saw the release of the Compute Module, a miniature Raspberry Pi in a small form factor designed for industrial and embedded applications, which would soon become the largest market for the computers. In July the Model B+ was released with a refined design featuring additional USB ports and a more efficient board layout that established the form factor for future models.[51][52] A smaller, cheaper ($20) Model A+ was released in November.[53] A significant leap in performance came in February 2015 with the Raspberry Pi 2, which featured a 900 MHz quad-core CPU and 1 GB of RAM.[54] Following its

release, the price of the Model B+ was lowered to $25, a move some observers linked to the emergence of lower-priced competitors.[55][56]

The Raspberry Pi Zero, launched in November 2015, radically redefined the entry point for computing at a price of just $5.[57] In February 2016, the Raspberry Pi 3 marked another major milestone by integrating a 64-bit processor, Wi-Fi, and Bluetooth.[58] The product line continued to expand with the wireless-enabled Raspberry Pi Zero W (February 2017),[59][60] the faster Raspberry Pi 3B+ (March 2018),[61] Raspberry Pi 3A+ (November 2018),[62] and Compute Module 3+ (January 2019).[63]

The Raspberry Pi 4, launched in June 2019, represented another major performance leap with a faster processor, up to 8 GB of RAM, dual-monitor support, and USB 3.0 ports.[64] A compute module version (CM4) launched in October 2020.[65] This era saw further diversification with the Raspberry Pi 400 (a computer integrated into a keyboard) in November 2020,[66] and the Raspberry Pi Pico in January 2021. The Pico, based on the in-house designed RP2040 chip, marked the company's first entry into the low-cost microcontroller market.[67] The Raspberry Pi Zero 2 W, introduced in 2021, featured a faster processor, providing a significant performance boost while maintaining the low-cost, compact form factor.[68]

The global chip shortage starting in 2020, as well as an uptake in demand starting in early 2021, notably affected the Raspberry Pi, causing significant availability issues from that time onward.[69] The company explained its approach to the shortages in 2021,[70] and April 2022,[71] explaining that it was prioritising business and industrial customers.

The Raspberry Pi 5 was released in October 2023, featuring an upgraded CPU and GPU, up to 16 GB of RAM, a PCIe interface for fast peripherals and an in-house designed southbridge chip.[72][73] Updated versions of the Compute Module (CM5) and keyboard computer (Pi 500) based on the Pi 5's architecture were subsequently announced.[74] The Raspberry Pi Pico 2, released in 2024, introduced the RP2350 microcontroller, featuring selectable dual-core 32-bit ARM Cortex-M33 or RISC-V processors, 520 KB of RAM, and 4 MB of flash memory.[75]

Sales Milestones

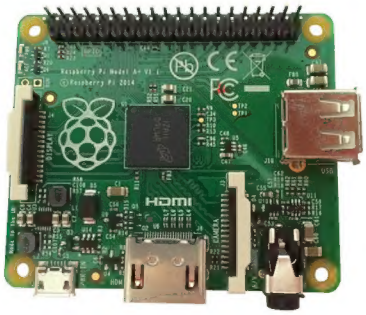
The Raspberry Pi's sales demonstrated remarkable growth. The one-millionth Pi was sold by October 2013,[76] a figure that doubled just a month later.[77] By February 2016, sales reached eight million units, surpassed the ZX Spectrum as the best-selling British computer of all time.[78][58] Sales hit ten million in September 2016,[79] thirty million by December 2019,[80] and forty million by May 2021.[81] As of its tenth anniversary in February 2022, a total of 46 million Raspberry Pis had been sold.[82] As of March 2025, 68 million units had been sold.[83]

Series and generations

There are five main series of Raspberry Pi computers, each with multiple generations. Most models feature a Broadcom system on a chip (SoC) with an integrated ARM-based central processing unit (CPU) and an on-chip graphics processing unit (GPU). The exception is the Pico series, a microcontroller which uses the RP2040, a custom-designed SoC with an ARM-compatible CPU but no GPU.

Flagship series

Original Raspberry Pi Model B, introduced in 2012



Raspberry Pi Model A+, introduced in 2014

Raspberry Pi 5, introduced in 2023

The flagship Raspberry Pi series, often referred to simply as "Raspberry Pi", offers high-performance hardware, a full Linux operating system, and a variety of common ports in a compact form factor roughly the size of a credit card.

- The **Model B** (2012) features a 700 MHz single-core 32-bit ARM11 CPU, a VideoCore IV GPU, 512 MB RAM and a 26-pin GPIO header.

- The **Model A** (2013) is a lower-cost version with 256 MB RAM, no Ethernet, and fewer USB ports.
- The **Model B+** and **Model A+** (2014) add a 40-pin GPIO header, microSD card support, and replace the RCA video connector with a combined 3.5 mm audio/video jack.
- The **Raspberry Pi 2 Model B** (2015) includes a 900 MHz quad-core Cortex-A7 CPU and 1 GB of RAM.
- The **Raspberry Pi 3 Model B** (2016) features a 1.2 GHz quad-core 64-bit Cortex-A53 CPU, Wi-Fi, Bluetooth, and USB boot support.
- The **Raspberry Pi 3 Model B+** (2018) upgrades to a 1.4 GHz CPU, faster Ethernet, dual-band Wi-Fi, and Power over Ethernet (PoE) support.
- The **Raspberry Pi 3 Model A+** (2018) is the final A-series model, offering the same features as the 3B+, but with 512 MB RAM and in a smaller form factor.
- The **Raspberry Pi 4** (2019) introduces a 1.5 GHz quad-core Cortex-A72 CPU, a VideoCore VI GPU, USB 3.0 ports, true Gigabit Ethernet, support for dual 4K monitors, and options for 1, 2, 4, or 8 GB of RAM.
- The **Raspberry Pi 5** (2023) features a 2.4 GHz quad-core Cortex-A76 CPU, a VideoCore VII GPU, PCIe support, and options for 2, 4, 8, or 16 GB of RAM. It omits the 3.5 mm audio/video jack.[84][85]

Keyboard series

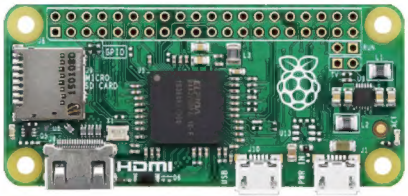
Raspberry Pi 400, introduced in 2020

The Keyboard series combines Raspberry Pi hardware and ports into a keyboard computer form factor, providing a self-contained Linux-based desktop system.

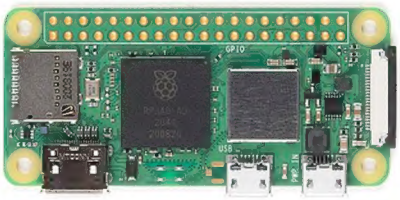
- The **Raspberry Pi 400** (2020) features a custom board based on the Pi 4. It includes a 1.8 GHz quad-core Cortex-A72 processor, 4 GB of RAM, and a large integrated heat sink. It supports dual 4K monitors via two micro HDMI ports and includes gigabit Ethernet.[86][87]
- The **Raspberry Pi 500** (2024) is based on the Pi 5 and succeeds the Pi 400. It features a 2.4 GHz quad-core Cortex-A76 processor and 8 GB of RAM. Unlike the Raspberry Pi 5, it lacks

a PCIe interface.[74][88][89]

Zero series



The Raspberry Pi Zero, introduced in 2015

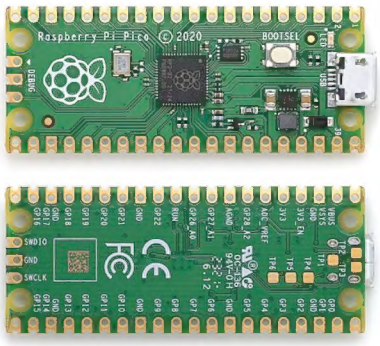


The Raspberry Pi Zero 2 W, introduced in 2021

The Raspberry Pi Zero series are compact, low-cost, and low-power single-board computers that provide basic functionality and Linux compatibility for embedded and minimalist computing applications.

- The **Raspberry Pi Zero** (2015), priced at US$5, features a 1 GHz single-core ARM11 CPU, 512 MB of RAM, mini HDMI, and micro USB ports for data and power. It includes an unpopulated 40-pin GPIO header.
  - The **Zero v1.3** (2016) added a camera connector.[90]
  - The **Zero W** (2017) introduced onboard Wi-Fi and Bluetooth for US$10.[91]
  - The **Zero WH** (2018) added pre-soldered GPIO pins for US$15.[92]
- The **Raspberry Pi Zero 2 W** (2021), priced at US$15, features a quad-core 64-bit ARM Cortex-A53 CPU and includes wireless connectivity. The **Zero 2 WH** variant adds a pre-soldered GPIO header for US$18.[68]

Pico series



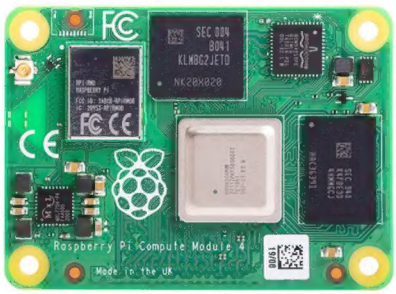
The Raspberry Pi Pico, introduced in 2021

The Pico series are compact microcontroller boards based on Raspberry Pi-designed chips. Unlike other models, they do not run Linux or support removable storage, and are instead programmed by flashing binaries to onboard flash memory.

- The **Raspberry Pi Pico** (2021) was the first board based on the in-house RP2040 microcontroller. It features a dual-core 32-bit ARM Cortex-M0+ CPU, 264 KB of RAM, and 2 MB of flash memory, priced at US$4.[93][67] The **Pico W** (2022) adds Wi-Fi and Bluetooth and launched at US$6.[94] The board has a castellated edge for direct soldering to a carrier board; versions are available with pre-soldered, bottom-mounted header pins, the **Pico H** for US$5 and the **Pico WH** for US$7.
- The **Raspberry Pi Pico 2** (2024) introduced the RP2350 microcontroller, featuring selectable dual-core 32-bit ARM Cortex-M33 or RISC-V processors, 520 KB of RAM, and 4 MB of flash memory, priced at US$5.[75] The **Pico 2 W** adds Wi-Fi and Bluetooth for US$7.[95]

Compute Module series

Raspberry Pi Compute Module 3



Raspberry Pi Compute Module 4

The **Compute Module** (CM) series delivers Raspberry Pi's flagship hardware in a compact form for industrial and embedded applications, omitting onboard ports and GPIO headers in favour of a carrier board interface.[96] Compute Modules are offered in one of two formats: a board matching the physical dimensions of a DDR2 SO-DIMM RAM module (though electrically incompatible with standard SO-DIMM sockets) and a smaller board with dual 100-pin high-density connectors that enables additional interfaces.[97]

- **Compute Module 1** (2014) – Based on the original Raspberry Pi. Features a single-core ARM11 CPU, 512 MB RAM, and 4 GB eMMC flash storage. SO-DIMM form factor.[98]
- **Compute Module 3** (2017) – Based on the Pi 3. Includes a quad-core 64-bit Cortex-A53 CPU, 1 GB RAM, and 4 GB eMMC; also available as a "Lite" variant without eMMC. SO-DIMM form factor.[97]

- **Compute Module 3+** (2019) – Based on the Pi 3+. Offers 0 (Lite), 8, 16, or 32 GB eMMC options. SO-DIMM form factor.[97]
- **Compute Module 4** (2020) – Based on the Pi 4. Includes a quad-core 64-bit Cortex-A72 CPU, 1, 2, 4, or 8 GB RAM, and 0 (Lite), 8, 16, or 32 GB eMMC; optional Wi-Fi and Bluetooth. High-density connector form factor; CM4S variant uses SO-DIMM form factor.[97]
- **Compute Module 5** (2024) – Based on the Pi 5. Features a quad-core 64-bit Cortex-A76 CPU, 2, 4, 8, or 16 GB RAM, and 0 (Lite), 16, 32, or 64 GB eMMC; optional Wi-Fi and Bluetooth. High-density connector form factor.[97][99]

Model/series comparison table

Series	Model	SoC	CPU	Memory	Ethernet	Wireless	USB	GPIO	Released	MSRP (US$)
Flagship Model B	1	BCM2835	1 × ARM11	256 or 512 MB	100 Mbit	No	2 × 2.0	26-pin	2012	35
	1+			512 MB			4 × 2.0	40-pin	2014	
	2	BCM2836	4 × A7	1 GB					2015	
	3	BCM2837	4 × A53			Yes[a]			2016	
	3+				300 Mbit[b]	Yes[c]			2018	
	4	BCM2711[100]	4 × A72	1, 2, 4 or 8 GB	Gigabit		2 × 2.0 2 × 3.0		2019[101]	35–75
	5	BCM2712	4 × A76	2, 4, 8 or 16 GB					2024	50–120
Flagship Model A	1	BCM2835	1 × ARM11	256 or 512 MB	No	No	1 × 2.0	26-pin	2013	25
	1+							40-pin	2014	
	3+	BCM2837	4 × A53	512 MB		Yes[c]			2018	35
Keyboard	400	BCM2711	4 × A72	4 GB	Gigabit	Yes[c]	1 × 2.0 2 × 3.0	40-pin	2020	70
	500	BCM2712	4 × A76	8 GB					2024[102]	90
Zero	1	BCM2835	1 × ARM11	512 MB	No	Optional[d]	1 × 2.0	40-pin	2015	5–15
	2	BCM2710[e]	4 × A53						2021	15–18
Pico	1	RP2040	2 × M0+	264 KB	No	Optional[d]	1 × 2.0	40-pin	2021	4–7
	2	RP2350	2 × M33	520 KB					2024	5–7
Compute Module	1	BCM2835	1 × ARM11	512 MB	No[f]	No	No[f]	No[f]	2014	30
	3/3+	BCM2837	4 × A53	1 GB					2017	25–40
	4	BCM2711	4 × A72	1, 2, 4 or 8 GB		Optional[d]			2020	25–85
	5	BCM2712	4 × A76	2, 4, 8 or 16 GB					2024	45–135

Notes

a. 2.4 GHz band only

b. Gigabit Ethernet; Throughput limited to ca. 300 Mbit/s by the internal USB 2.0 connection

c. 2.4/5 GHz dual band

d. "W" models only, 2.4 GHz band

e. Custom Raspberry Pi SiP RP3A0

f. Signals routed through board connector

Hardware

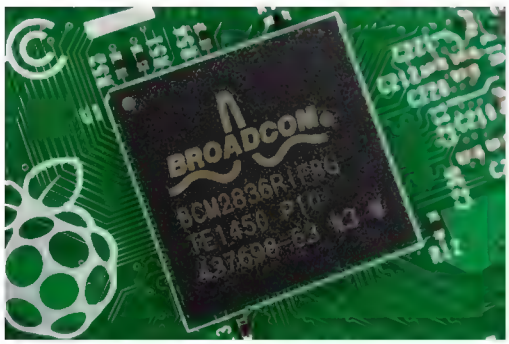
The Raspberry Pi has undergone multiple hardware revisions, with changes in processor type, memory capacity, networking features, and peripheral support.[103]

Processor speeds have ranged from 700 MHz on early models to 2.4 GHz on the Raspberry Pi 5. RAM has increased from 256 MB on the original model to up to 16 GB on the Pi 5. Storage is typically provided via a SD card, though some Compute Module variants include onboard eMMC storage.[104] Newer models also support booting from USB-attached drives, and the Pi 5 can boot from NVMe drives connected via the PCIe interface.[105][106] Digital video and audio output to a display is offered via HDMI.

Most models include a GPIO (general-purpose input/output) header that provides power and supports multiple low-speed interfaces. This header allows connection to various accessories and custom hardware.

Networking capabilities vary by model. B-model boards feature a wired Ethernet port, while most models produced after the Pi 3 include built-in Wi-Fi and Bluetooth.[107]

Processors and system-on-chip



BCM2836 on a Pi 2 board

Raspberry Pi boards have used various system on a chip (SoC) designs developed in partnership with Arm and Broadcom, with each generation introducing improvements in performance and capability.

The original Raspberry Pi used the BCM2835, featuring a 700 MHz single-core ARM11 processor and a VideoCore IV GPU, which remained in use through the Pi 3 series.[108][109] The Raspberry Pi Zero and Zero W also use the BCM2835, but with the CPU clocked at 1 GHz.[110]

The Raspberry Pi 2 introduced the BCM2836 with a 900 MHz quad-core 32-bit Cortex-A7 CPU.[111] A later revision (V1.2) used the 64-bit BCM2837 with a Cortex-A53 CPU, also clocked at 900 MHz.[112] The Raspberry Pi 3 retained the BCM2837, with the CPU clocked up to 1.4 GHz in later models.[113][114][115] The Raspberry Pi Zero 2 W uses the RP3A0, a system in a package (SiP) containing a 64-bit quad-core BCM2710 processor with a Cortex-A53 CPU clocked at 1 GHz and 512 MB of LPDDR2 SDRAM stacked above.[116][117]

The Raspberry Pi 4 introduced the BCM2711, a 64-bit SoC with a quad-core Cortex-A72 processor running at 1.5 GHz (later increased to 1.8 GHz), a VideoCore VI GPU, and support for hardware virtualization.[118][119][120][121] The Raspberry Pi 5 features the BCM2712, with a quad-core Cortex-A76 processor running at 2.4 GHz, a VideoCore VII GPU at 800 MHz, cryptographic extensions, and a dedicated RP1 southbridge chip designed in-house.[122]

Raspberry Pi has also developed its own chips outside of its partnership with Broadcom. The Raspberry Pi Pico uses the RP2040, featuring dual-core 32-bit Cortex-M0+ processors running at 133 MHz and 264 kB of on-chip RAM.[123][124] The Pico 2 uses the RP2350, which can operate with either dual-core Cortex-M33 or dual-core Hazard3 RISC-V CPUs selected at boot, running at 150 MHz, with 520 kB of RAM.[125][126]

Overclocking

Most Raspberry Pi systems support overclocking to increase performance, which can be enabled by editing the device's configuration file. On newer models, CPU frequency is managed dynamically, the system adjusts clock speeds based on processor load—increasing frequency during heavy use and lowering it when idle—to balance performance, power consumption, and heat generation. Although this behavior can resemble overclocking, it operates within standard specifications and is part of normal power management. The system automatically reduces performance if the CPU temperature reaches 85 °C (185 °F), or if undervoltage is detected. Additional cooling, such as a heat sink or fan, may be required for sustained high-performance use.[127][128]

RAM

The original Raspberry Pi models featured 256 MB of random-access memory (RAM), initially split evenly between the CPU and GPU.[129] A 512 MB Model B was introduced in October 2012, with support for dynamic GPU memory assignment.[130] The Raspberry Pi Zero and Zero 2 also include 512 MB of RAM.

The Raspberry Pi 2 increased RAM to 1 GB. This continued with the Raspberry Pi 3, which includes 1 GB in the B and B+ models and 512 MB in the A+.

The Raspberry Pi 4 is available in 1, 2, 4 and 8 GB variants.[64] The Raspberry Pi 5 is available with 2, 4, 8, or 16 GB of RAM, the highest capacity offered to date.[131]

Peripherals

The Model 2B boards incorporate four USB Type-A ports for connecting peripherals.

The Raspberry Pi works with most standard USB accessories like keyboards, mice, and flash drives. It can also connect to other hardware through its various ports and pins, depending on the software and drivers installed.[132][133]

Video

Raspberry Pi devices support a variety of video output options and screen resolutions.

Early models, such as the original Model A and Model B, feature a full-size HDMI port for digital video and audio, as well as an RCA connector for analog composite video output. The RCA port was removed in later revisions to save board space, but composite video output remains supported via the 3.5 mm TRRS jack or dedicated solder points on the board. According to the Raspberry Pi Foundation, this continued support helps maintain accessibility in developing countries.[134] Supported analog video standards include PAL, NTSC, and their regional variants.[135]

To accommodate smaller boards and newer features, video connectors have evolved across models. The Raspberry Pi Zero uses a mini-HDMI connector, while the Raspberry Pi 4 and 5 use dual micro-HDMI ports. This change enables support for multiple displays: the Pi 4 can drive two 4K displays at 30 Hz or a single 4K display at 60 Hz, while the Pi 5 improves on this with support for two 4K displays at 60 Hz.[136][137]

Most Raspberry Pi models support common display resolutions such as 720p and 1080p by default, with some capable of higher resolutions depending on hardware and configuration. In

some cases, output up to 2048×1152 or 3840×2160 (4K) is possible, though performance at these resolutions may vary.[138][139]

GPIO header

Most Raspberry Pi models include a 40-pin connector known as the GPIO (general-purpose input/output) header, although only some of the pins are dedicated to GPIO functions. The header, designated as J8, uses a consistent pinout across models.

The header supplies 3.3 V and 5 V power along with various multiplexed, low-speed interfaces, including UART, SPI, I²C, I²S, and PCM.[72] GPIO pins can be configured as either inputs or outputs. When set as an output, a pin can drive a high (3.3 V) or low (0 V) signal. When configured as an input, it can read a high (3.3 V) or low (0 V) voltage level.[140]

The original Raspberry Pi 1 Model A and B include only the first 26 pins of this header.[141][142][143] On some Pi Zero models, the header is unpopulated, but solderable through-holes are provided. The Pico models feature a unique layout with unpopulated through-holes and a castellated edge, allowing it to be surface-mounted as a module. Compute Module boards do not include GPIO headers but instead expose GPIO signals through their board connectors.

Function	Pin #		Function
+3.3 V power	1	2	+5 V power
GPIO 2 (I²C SDA)	3	4	+5 V power
GPIO 3 (I²C SCL)	5	6	Ground
GPIO 4 (GPCLK)	7	8	GPIO 14 (UART TXD)
Ground	9	10	GPIO 15 (UART RXD)
GPIO 17	11	12	GPIO 18
GPIO 27	13	14	Ground
GPIO 22	15	16	GPIO 23
+3.3 V power	17	18	GPIO 24
GPIO 10 (SPI MOSI)	19	20	Ground
GPIO 9 (SPI MISO)	21	22	GPIO 25
GPIO 11 (SPI SCLK)	23	24	GPIO 8 (SPI CE0)
Ground	25	26	GPIO 7 (SPI CE1)
GPIO 0 (EEPROM SDA)	27	28	GPIO 1 (EEPROM SDC)
GPIO 5	29	30	Ground
GPIO 6	31	32	GPIO 12
GPIO 13	33	34	Ground
GPIO 19	35	36	GPIO 16
GPIO 26	37	38	GPIO 20 (PCM_DIN)
Ground	39	40	GPIO 21 (PCM_DOUT)

Legend

SPI · I²C · PCM · +5 V · GPIO · UART · Ground · +3.3 V

Networking

Most Raspberry Pi models include built-in options for connecting to the internet. The Model B and B+ include a basic Ethernet port. Starting with the Raspberry Pi 3, most models come with built-in WiFi and Bluetooth. The Raspberry Pi 3B+ adds faster dual-band WiFi and limited gigabit Ethernet. The Raspberry Pi 4 and 5 offer full gigabit Ethernet with no speed limitations.[144] The

"A" models and the Pi Zero series do not have Ethernet ports, so they require a separate USB adapter for wired or wireless connections.

Special-purpose features

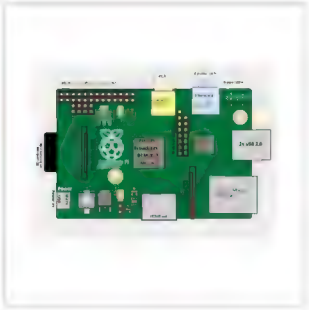
Some Raspberry Pi models, like the Zero, 1A, 3A+, and 4, can act like a USB device (via the USB On-The-Go protocol) when plugged into another computer.[145] This lets them work as gadgets such as a virtual keyboard, network adapter, or serial device.[146]

Many newer models can also start up (or "boot") directly from a USB drive, without needing a microSD card. This feature isn't available on older models like the original Raspberry Pi, Pi Zero, or early versions of the Pi 2.[147]

Real-time clock

Most Raspberry Pi models do not include a built-in real-time clock, which means they rely on an internet connection to set the correct time with the Network Time Protocol when they start up. If there's no connection, the time must be set manually or the system assumes no time has passed since it was last used. Add-on clock modules are available for situations where accurate timekeeping is needed without internet access.[148][149] The Raspberry Pi 5 is the first model to include a built-in clock, but it still needs a battery backup to keep time when powered off.[150]

Board layouts



Pi 1B v1.2

Pi 1A

Pi 1A+ v1.1

Pi 1B+ v1.2 and Pi 2

Pi 3

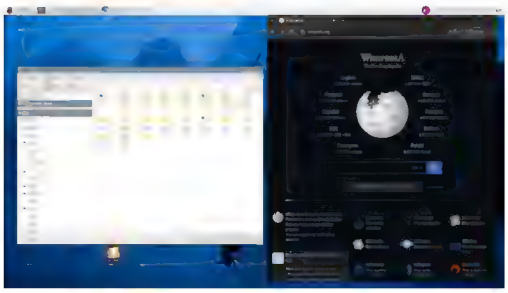
Pi 3+

Pi 4

Pi 5

Software

Operating systems



Raspberry Pi OS "Bookworm", showing the file manager and Chromium, the default web browser.

The recommended operating is Raspberry Pi OS, a Debian-based Linux distribution optimized for performance and energy efficiency on Raspberry Pi hardware. It is available in both 32-bit and 64-bit versions and comes in several editions: a full version with preinstalled software, a "Lite" edition without a desktop environment, and a minimal version with fewer preinstalled applications.

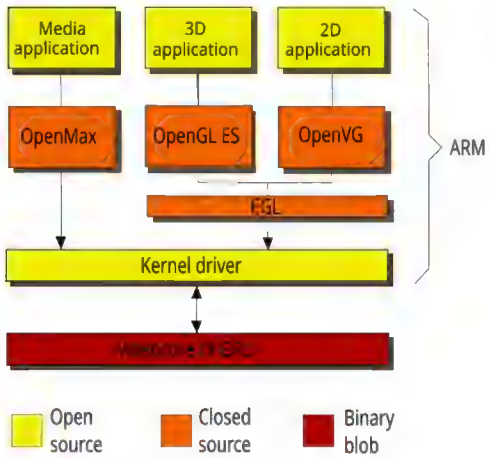
Raspberry Pi OS can be purchased pre-installed on a microSD card,[151] or downloaded and installed using Raspberry Pi Imager, a utility introduced in March 2020 to simplify the installation

of operating systems onto SD cards and other media for Raspberry Pi devices. Available for macOS, Raspberry Pi OS, Ubuntu, and Windows, Imager allows users to download and write operating system disk images within a single application.[152] In addition to Raspberry Pi OS, the utility supports a variety of third-party operating systems, including Alpine Linux,[153] Android,[154] Armbian,[155] FreedomBox,[156] Kali Linux,[157] LibreELEC,[158] RetroPie,[159] RISC OS,[160] SatNOGS,[161] and Ubuntu.[162]

Firmware

The Raspberry Pi uses official firmware that is proprietary, meaning its source code is not publicly available, but the binary blob can be freely redistributed.[163][164] An experimental open-source alternative to the official firmware is also available. Although limited in functionality, it demonstrates that it is possible to start the Raspberry Pi's ARM processor cores and boot a basic version of the Linux kernel without relying on the proprietary components. This is significant for developers and advocates who aim to build fully open systems.[165]

Driver APIs



Scheme of the implemented APIs: OpenMAX IL, OpenGL ES and OpenVG

Raspberry Pi systems use Broadcom's VideoCore GPU, which requires a proprietary binary blob to be loaded at boot. Initially, the supporting software stack was entirely proprietary,[166] though parts of the code were later released.[49] Most driver functionality remains within closed-source GPU firmware, accessed via runtime libraries such as OpenMAX IL, OpenGL ES, and OpenVG. These libraries interface with a kernel-space open-source driver, which in turn communicates with the closed GPU firmware. Applications use OpenMAX IL for video, OpenGL ES for 3D graphics, and OpenVG for 2D graphics, with all graphics libraries making use of EGL.[167]

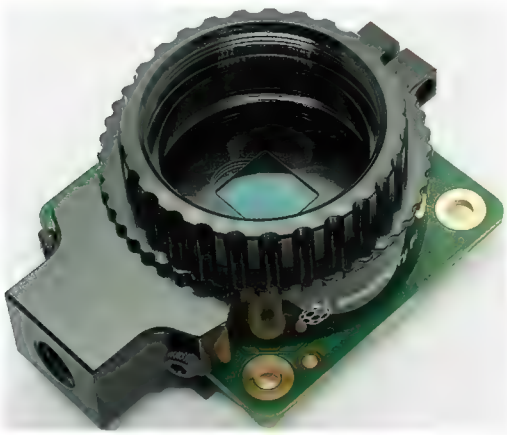
In February 2020, Raspberry Pi announced the development of a Vulkan graphics driver.[168] A working prototype demonstrated high performance in Quake III Arena on a Raspberry Pi 3B+ later

that year.[169] On 24 November 2020, Raspberry Pi 4's Vulkan driver was declared Vulkan 1.0 conformant,[170] with subsequent conformance updates for versions 1.1[171] and 1.2.[172]

Official accessories

Cameras

Camera Module (original)



High Quality Camera Module

Raspberry Pi offers several official camera modules that connect via CSI and are designed for photography, video capture, and machine vision applications:

- **Camera Module** (2013) – The initial 5-megapixel (MP) camera based on the OmniVision OV5647 sensor. It supports up to 1080p video.[173] Also offered in a "NoIR" version with no infrared filter.[174]
- **Camera Module 2** (2016) – A 8 MP module based on the Sony IMX219 sensor, also offered in NoIR variants.[175]
- **High Quality Camera** (2020) – A 12.3 MP camera using the Sony IMX477 sensor. Intended at advanced photography and industrial use cases, it supports either C/CS mount or M12 mount interchangeable lenses and has a tripod mount.[176]

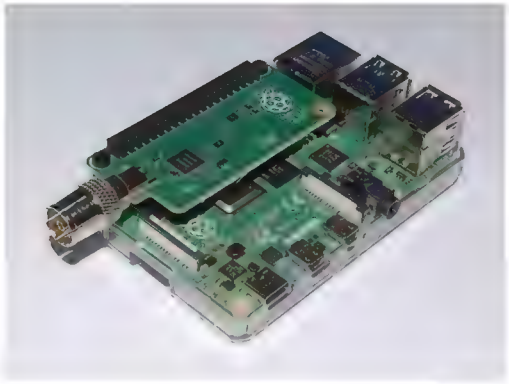
- **Camera Module 3** (2023) – A 12 MP camera module featuring a Sony IMX708 sensor with autofocus and HDR support. Priced at US $25 (standard/NoIR) and US $35 (wide-angle variants).[177][178]
- **Global Shutter Camera** (2023) – A camera module with a 1.6 MP Sony IMX296 global shutter sensor. Intended for fast motion photography and machine vision, it supports C/CS mount interchangeable lenses and has a tripod mount.[179]
- **AI Camera** (2024)– A 12.3 MP camera using the Sony IMX500 sensor, which includes on-sensor AI processing capabilities for vision applications.[180]

Displays

Raspberry Pi also offers official display peripherals for graphical and touchscreen interfaces:

- **Raspberry Pi Touch Display** (2015) – A 7-inch capacitive touchscreen.[181]
- **Raspberry Pi Touch Display 2** (2024) – A revised version of the original 7-inch touchscreen display with improved performance and compatibility.[182]
- **Raspberry Pi Monitor** (2024) – A 15.6-inch Full HD IPS display with built-in speakers and folding stand.[183]

Add-on boards (HATs)



Raspberry Pi 4 Model B with a "TV Hat" card (for DVB-T/T2 television reception) attached

Official Raspberry Pi HATs (Hardware Attached on Top) and expansion boards extend the functionality of Raspberry Pi computers. The HAT standard was introduced in July 2014. Many boards use an EEPROM for automatic configuration.[184][185]

- **AI HAT+** (2024) – A HAT for the Raspberry Pi 5 featuring a built-in Hailo chip providing 13 or 26 TOPS of AI acceleration.[186][187]
- **M.2 HAT+** (2024) – A HAT for the Raspberry Pi 5 featuring an interface for attaching M.2 peripherals such as NVMe SSDs and AI accelerators.
  - **AI Kit** (2024) – A bundle including the M.2 HAT+ and a Hailo AI accelerator module.

    - **SSD Kit** (2024) – A bundle including the M.2 HAT+ and a NVMe SSD.[188]
- **Sense HAT** (2015) – Includes sensors for temperature, humidity, pressure, orientation, and a 8×8 LED matrix with a joystick. Originally part of the Astro Pi project.[189]
- **PoE+ HAT** – Enables Power over Ethernet functionality for models with PoE support.
- **Build HAT** – Designed to interface with Lego Technic motors and sensors.
- **TV HAT** (2018) – Allows reception and decoding of digital DVB-T2 television broadcasts.[190]
- **DAC+ / DAC Pro / DigiAMP+** – A range of audio HATs offering high-resolution digital-to-analog conversion, with the DigiAMP+ including a built-in amplifier.
- **Codec Zero** – A compact audio input/output board sized for the Raspberry Pi Zero.

Power supplies

- **Build HAT Power Supply** – Power adapter used with the Build HAT to support connected motors and sensors.[191]
- **PoE+ Injector** (2018) – Provides Power over Ethernet (up to 30 W) for compatible models using a PoE HAT.[192]
- **USB Power Supplies** – Available in multiple versions delivering 5.1 V at different power levels: 12.5 W via Micro-USB for earlier models, 15 W via USB-C for Pi 4, 27 W via USB-C for Pi 5, and 45 W via USB-C for third-party laptops.[193]

Peripherals

- **Active Cooler** (2023) – A heatsink and temperature-controlled fan for thermal management on Pi 5.[194]
- **Cables and adapters** – Includes HDMI (micro for Pi 4/5, mini for Zero), USB (micro-USB and USB-C), and various adapters for display and peripheral connectivity.[195]
- **Cases** – Plastic enclosures for Raspberry Pi A+, 3, 4, 5, and Zero series with venting, and in some cases fans, to aid heat dissipation.[196] A minimalist "bumper case" silicone enclosure is also offered for the Pi 5.[197]
- **Keyboard and Mouse** – Official USB keyboard (with integrated hub with three USB 2 Type-A ports) and optical mouse designed for use with Raspberry Pi.[198]
- **SD Cards** – Officially tested microSD cards that support A2 command queueing, C10 card speeds, and SDR104 bus speeds.[199]
- **USB 3 Hub** – Adds four additional USB 3 Type-A ports, also includes a USB-C power input to support high power draw peripherals.[200]

Debugging and utility

- **Debug Probe** (2022) – RP2040-based hardware debug tool for Raspberry Pi and RP2040 development boards.[201]
- **RTC Battery** (2024) – Rechargeable lithium battery for powering the real-time clock on Raspberry Pi 5 during power loss.[202]

Reception and use

NASA's *Open Source Rover* powered by a Raspberry Pi 3

Technology writer Glyn Moody described the project in May 2011 as a "potential BBC Micro 2.0", not by replacing PC compatible machines but by supplementing them.[203] In March 2012 Stephen Pritchard echoed the BBC Micro successor sentiment in *ITPRO*.[204] Alex Hope, co-author of the Next Gen report, is hopeful that the computer will engage children with the excitement of programming.[205] Co-author Ian Livingstone suggested that the BBC could be involved in building support for the device, possibly branding it as the BBC Nano.[206] The Centre for Computing History strongly supports the Raspberry Pi project, feeling that it could "usher in a new era".[207] Before release, the board was showcased by ARM's CEO Warren East at an event in Cambridge outlining Google's ideas to improve UK science and technology education.[208]

Harry Fairhead, however, suggests that more emphasis should be put on improving the educational software available on existing hardware, using tools such as Google App Inventor to return programming to schools, rather than adding new hardware choices.[209] Simon Rockman, writing in a *ZDNet* blog, was of the opinion that teens will have "better things to do", despite what happened in the 1980s.[210]

In October 2012, the Raspberry Pi won T3's Innovation of the Year award,[211] and futurist Mark Pesce cited a (borrowed) Raspberry Pi as the inspiration for his ambient device project MooresCloud.[212] In October 2012, the British Computer Society responded to the announcement of enhanced specifications by stating, "it's definitely something we'll want to sink our teeth into."[213]

In June 2017, Raspberry Pi won the Royal Academy of Engineering MacRobert Award.[214] The citation for the award to the Raspberry Pi said it was "for its inexpensive credit card-sized

microcomputers, which are redefining how people engage with computing, inspiring students to learn coding and computer science and providing innovative control solutions for industry."[215]

Clusters of hundreds of Raspberry Pis have been used for testing programs destined for supercomputers.[216]

Community

The Raspberry Pi community was described by Jamie Ayre of FOSS software company AdaCore as one of the most exciting parts of the project.[217] Community blogger Russell Davis said that the community strength allows the Foundation to concentrate on documentation and teaching.[217] The community developed a fanzine around the platform called *The MagPi*[218] which in 2015, was handed over to Raspberry Pi (Trading) Ltd by its volunteers to be continued in-house.[219] A series of community *Raspberry Jam* events have been held across the UK and around the world.[220]

Education

As of January 2012, enquiries about the board in the United Kingdom have been received from schools in both the state and private sectors, with around five times as much interest from the latter. It is hoped that businesses will sponsor purchases for less advantaged schools.[221] The CEO of Premier Farnell said that the government of a country in the Middle East has expressed interest in providing a board to every schoolgirl, to enhance her employment prospects.[222][223]

In 2014, the Raspberry Pi Foundation hired a number of its community members including ex-teachers and software developers to launch a set of free learning resources for its website.[224] The Foundation also started a teacher training course called Picademy with the aim of helping teachers prepare for teaching the new computing curriculum using the Raspberry Pi in the classroom.[225]

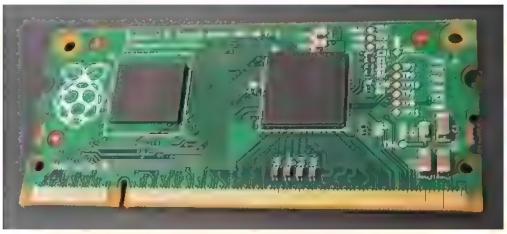
In 2018, NASA launched the *JPL Open Source Rover Project*, which is a scaled down version of Curiosity rover and uses a Raspberry Pi as the control module, to encourage students and hobbyists to get involved in mechanical, software, electronics, and robotics engineering.[226]

Home automation

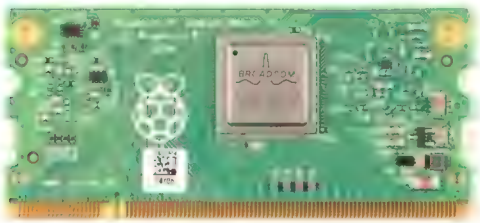
There are a number of developers and applications that are using the Raspberry Pi for home automation. These programmers are making an effort to modify the Raspberry Pi into a cost-affordable solution in energy monitoring and power consumption. Because of the relatively low

cost of the Raspberry Pi, this has become a popular and economical alternative to the more expensive commercial solutions.

Industrial automation



Compute Module 1



Compute Module 3+

In June 2014, Polish industrial automation manufacturer TECHBASE released ModBerry, an industrial computer based on the Raspberry Pi Compute Module. The device has a number of interfaces, most notably RS-485/232 serial ports, digital and analogue inputs/outputs, CAN and economical 1-Wire buses, all of which are widely used in the automation industry. The design allows the use of the Compute Module in harsh industrial environments, leading to the conclusion that the Raspberry Pi is no longer limited to home and science projects, but can be widely used as an Industrial IoT solution and achieve goals of Industry 4.0.[227]

In March 2018, SUSE announced commercial support for SUSE Linux Enterprise on the Raspberry Pi 3 Model B to support a number of undisclosed customers implementing industrial monitoring with the Raspberry Pi.[228]

In January 2021, TECHBASE announced a Raspberry Pi Compute Module 4 cluster for AI accelerator, routing and file server use. The device contains one or more standard Raspberry Pi Compute Module 4s in an industrial DIN rail housing, with some versions containing one or more Coral Edge tensor processing units.[229]

Commercial products

The Organelle is a portable synthesiser, a sampler, a sequencer, and an effects processor designed and assembled by Critter & Guitari. It incorporates a Raspberry Pi computer module running Linux.[230]

OTTO is a digital camera created by Next Thing Co. It incorporates a Raspberry Pi Compute Module. It was successfully crowd-funded in a May 2014 Kickstarter campaign.[231]

Slice is a digital media player which also uses a Compute Module as its heart. It was crowd-funded in an August 2014 Kickstarter campaign. The software running on Slice is based on Kodi.[232]

Numerous commercial thin client computer terminals use the Raspberry Pi.[233]

COVID-19 pandemic

During the COVID-19 pandemic, demand increased primarily due to the increase in remote work, but also because of the use of many Raspberry Pi Zeros in ventilators for COVID-19 patients in countries such as Colombia,[234] which were used to combat strain on the healthcare system. In March 2020, Raspberry Pi sales reached 640,000 units, the second largest month of sales in the company's history.[235]

In space

A project was launched in December 2014 at an event held by the UK Space Agency. The Astro Pi was an augmented Raspberry Pi that included a sensor hat with a visible light or infrared camera. The Astro Pi competition, called Principia, was officially opened in January and was opened to all primary and secondary school aged children who were residents of the United Kingdom. During his mission, British ESA astronaut Tim Peake deployed the computers on board the International Space Station.[236] He loaded the winning code while in orbit, collected the data generated and then sent this to Earth where it was distributed to the winning teams. Covered themes during the competition included spacecraft sensors, satellite imaging, space measurements, data fusion and space radiation.

The organisations involved in the Astro Pi competition include the UK Space Agency, UKspace, Raspberry Pi, ESERO-UK and ESA.

In 2017, the European Space Agency ran another competition open to all students in the European Union called Proxima. The winning programs were run on the ISS by Thomas Pesquet, a French astronaut.[237] In December 2021, the Dragon 2 spacecraft launched by NASA had a pair of Astro Pi in it.[238]

See also

- Single-board computer
- Plug computer

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Further reading

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- *Getting Started with Raspberry Pi*; Matt Richardson and Shawn Wallace; 2013; ISBN 978-1449344214.
- *Raspberry Pi User Guide*; Eben Upton and Gareth Halfacree; 2014; ISBN 978-1118921661.
- *Hello Raspberry Pi!*; Ryan Heitz; 2016; ISBN 978-1617292453.
- *The Official Raspberry Pi Beginner's Guide*; Gareth Halfacree; 2023; ISBN 978-1912047260.

External links

- Official website (https://www.raspberrypi.com)
- Raspberry Pi, Department of Computer Science and Technology, University of Cambridge (https://www.cl.cam.ac.uk/projects/raspberrypi/)
- Raspberry Pi Wiki, supported by the RPF (https://elinux.org/RaspberryPiBoard)

- *The MagPi Magazine* (https://magpi.raspberrypi.org/)
- "Raspberry Pi pinout" (https://www.panu.it/raspberry/) – board GPIO pinout
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- *ARM1176JZF-S (ARM11 CPU Core) Technical Reference Manual* (https://infocenter.arm.com/help/topic/com.arm.doc.ddi0301h/DDI0301H_arm1176jzfs_r0p7_trm.pdf) Archived (https://web.archive.org/web/20200619185015/http://infocenter.arm.com/help/topic/com.arm.doc.ddi0301h/DDI0301H_arm1176jzfs_r0p7_trm.pdf) 19 June 2020 at the Wayback Machine, ARM Ltd.